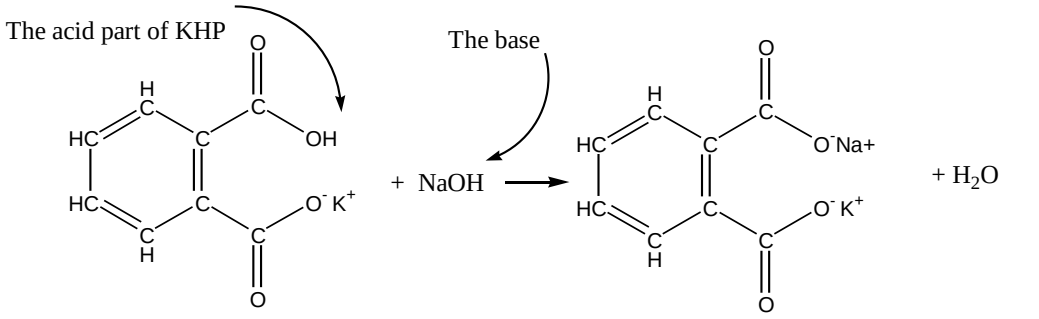
STANDARDIZING YOUR NaOH By TITRATION WITH KHP

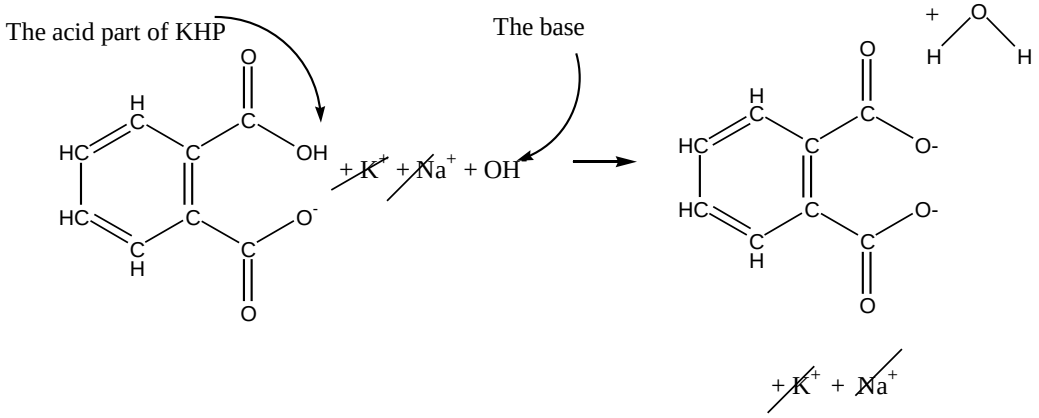
We will react the NaOH in your 0.1 M solution with an acid which is quite well-behaved. The acid is potassium hydrogen phthalate, KHP, and it is a solid that is easily weighed. If you weigh 0.2500 g of KHP, KHP is what you have, and nothing else. KHP is a PRIMARY STANDARD.

FIGURE 1



KHP, Potassium acid phthalate, $KHC_8H_4O_4$

MW = 204.2 g/mol

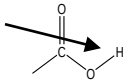


Lewis Acids accept a pair of electrons. Bases donate a pair of electron (Lewis definition).
Brønsted Acids donate H^+
Bases accept H^+ (Brønsted-Lowry definition)

ALL Brønsted acids are Lewis acids too, but **not all Lewis acids are Brønsted acids**

$$HP^- + OH^- \longrightarrow P^{=} + H_2O$$

1 mole of KHP will react with 1 mole of sodium hydroxide. This is an **ACID-BASE** reaction. KHP is an **acid**… this piece of the KHP donates an H^+ to the $^-$OH ion, which is a **base** (the Brønsted-Lowry definition) .



Also H^+ from KHP accepts a pair of electrons from the $^-$:OH ion (Lewis definition).

FIRST Calculate how much KHP you need:

a.  BEFORE YOU COME TO LAB, calculate how many moles of NaOH there are in 25.0 mL of 0.10 M NaOH (a convenient volume to use in a buret)

b.  BEFORE YOU COME TO LAB Calculate how many moles of KHP you will need to react with the moles of NaOH you calculated in part a above.

c.  BEFORE YOU COME TO LAB Calculate how many GRAMS of KHP corresponds to the number of moles of KHP you calculated in b above.

Standardize your NaOH at LEAST 3 times. 4 times is recommended. You will be scored on your precision, so the more times you repeat this, the better for you. Submit [NaOH] from each trial, the average and the standard deviation, and the % error.

PROTOCOL

NaOH is Caustic! Keep it off your skin and out of your eyes!

1. **Retrieve and shake up your 0.1 M NaOH solution**. 6 M NaOH is dense and tends to sit on the bottom of the flask, while less dense water sits on top. If the NaOH solution is not well mixed, your experiment WON'T WORK. Make sure the cap is on tightly and invert the bottle of solution at least 30 times.
2. **Obtain and clean a 50.00 mL buret and ringstand**. Drain it, and rinse it several times with distilled water. Each time you rinse it, make sure you open the stopcock and run distilled water through the tip. When the buret is clean, it will have some water in it. You are going to put your NaOH into the buret, so that you can determine what volume of NaOH is required to react with the KHP. You don't want to dilute your NaOH solution, so now;
3. **Rinse your buret with your NaOH solution**. Carefully pour about 5 mL of your well-mixed NaOH solution into your buret (Make sure the stopcock is closed!). At the sink, open the stopcock and drain a little solution through the tip. Close the stopcock. Now, tilt your buret down to near horizontal, twirl it to coat the walls with solution, and then discard the rinse solution. Repeat this process 3 more times. Now, return to your bench and;
4. **Fill your buret with your NaOH solution.** Fill the buret to close to the top, but DO NOT fill to the 0.00 line. This introduces error! Your eye tends to tell your brain what your brain wants…so your reading at 0.00 will be your **least** accurate reading! If your brain doesn't know what the reading is supposed to be, it will tend to pay more attention to what your eye is telling it. Despite this well known fact, the rare student will persist in trying to get the bottom of the meniscus exactly on the 0.00 mL line. If you do this, you should know that this is not only a waste of your time, but will cost you 5% off on your lab report.
5. **Read your buret volume & record it.** Read the volume on your buret (+/- 0.02 mL). Remember to read the bottom of the meniscus, with your sight-line level with the meniscus. Use a buret reading card. Record the volume in your notebook.

6. **Weigh** (+/- 0.0001 g) **the mass of KHP** required to react with 25 mL of 0.1 M NaOH you calculated before you came to lab. The KHP will have been dried in the oven at 120°C overnight to dry it. Record the mass in your notebook! Place it in a labeled ("1","2","3" …) clean , but need not be dry (really!) 125 mL ehrlenmeyer flask. Add about 10 mL of distilled water and swirl it about. If all the KHP doesn't dissolve, that's OK. (it will, as soon as you start titrating with NaOH). Set the labeled flask aside and weigh out 3 more samples of KHP. Record the mass of each.

7. **CLEAN UP THE BALANCE!**

You are almost ready to begin titrating.

Titration: a controlled reaction between a compound in which the number of moles of one reactant is known (the ***titrant***, a primary standard) and a measured volume of solution (dispensed from a buret) in which the number of moles of a different reactant is unknown (the ***analyte***). The analyte's concentration (moles/L) is then determined from the stoichiometry of the reaction and the volume of analyte dispensed from the buret.
Once the concentration of the analyte is determined in this way, it is ***standardized.*** That is, its concentration is known with great precision and accuracy.

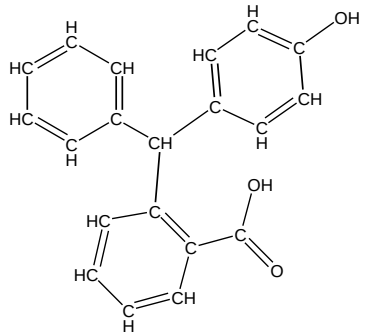
In today's lab, the titrant in primary standard KHP, & the analyte you will standardize is the NaOH solution. The reaction you will use to determine the [NaOH] is of course:

$KHP_{(aq)} + NaOH_{(aq)} \rightarrow KNaP_{(aq)} + H_2O_{(l)}$

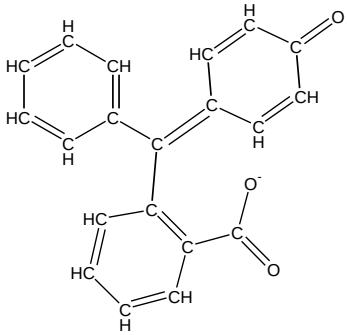
[NaOH] – square brackets around a chemical formula are an abbreviation for "concentration of the compound in moles/L"

1 mole of KHP will react with 1 mole of NaOH. Since you know the mass of KHP in your Ehrlenmeyer flask, and you know the molecular weight (204.2 g/mol) You can easily calculate the number of moles of KHP in each flask. If you can add just enough NaOH to react with the KHP, no less and no more, you would know how many moles of NaOH you had. If you also knew the volume, calculating the [NaOH] in moles/L is straightforward.

OK, so we have two problems. The first is, how do you know when you've added "just enough NaOH to react with the KHP, no less and no more", or, as one says in the trade, a "***stoichiometric amount***"? This is easy. You'll add an ***indicator*** which changes color when the reaction is done. You'll use 2 drops of 2% phenolphthalein in ethanol. Phenolphthalein is an ***acid-base*** indicator.



Phenolphthalein in acid...colourless



Phenolphthalein in excess OH^- fluorescent pink!

Initially, phenolphthalein will be in an acidic environment, KHP. (the H^+ in KHP is the acid). As you add NaOH, it will react with the KHP and the solution will remain colorless. But when the last of the KHP is reacted, the very next drop of NaOH you add from your buret will turn the solution in your flask a pale pink color. That is the ***endpoint*** of your titration.

So the phenolphthalein will tell you when you've added a stoichiometric amount of NaOH to the KHP. You know that you've added as many moles of NaOH as you had KHP to begin with. You need to determine how many moles of NaOH are in a liter of solution. The buret is the instrument designed to tell you what volume of NaOH you added. Get a buret reading at the beginning of your titration. Read the buret again at the endpoint. Subtract the two volumes and that, along with the mass of KHP, is all the data you need.

DOING THE TITRATION:

1. **Get your first labeled flask with the known and recorded mass of KHP.** Add 2 drops of phenolphthalein indicator to it. Set your magnetic stirrer up under the buret & make sure the buret tip has no drops dangling from the tip. If it does, rinse the tip with distilled water from your wash bottle into a waste beaker. Put your flask on the stirrer, and add a clean washed magnetic spin vane (it need not be dry) to the flask. Slowly turn on the stirrer until you get a nice gentle vortex. Once again, stirring is key!

Wash down the sides of your flask while titrating.

2. **Have you recorded your buret volume?** If not do it now, to the nearest 0.02 mL.
3. **Start adding NaOH.** Slowly open the stopcock and start running NaOH into your flask. Rinse down the sides of the flask from time to time with your wash bottle. Soon, you will see pink color forming around the drops of NaOH as they hit the solution. The pink color will rapidly disappear.
4. **Slow down!** As you move toward the endpoint, the pink color will fade more slowly. When this happens, slow down the rate at which you add NaOH. Add it one drop at a time. Rinse the sides and tip of the buret with distilled water from your wash bottle. As you go on, add NaOH slower. When the faint pink blush of phenolphthalein lasts for > 30 secs, you are done. You should be able to hit this endpoint +/- half a drop. Save your flask so you can match the faint pink color with your next endpoint.
5. **Record your buret reading +/-** 0.02 mL.
6. **Repeat steps 1-6 wih your other 3 flasks of previously massed and recorded KHP.**

That persistent faint pink blush of a good endpoint.

Calculate the [NaOH]: Report average [NaOH], sd, and % error.

Titration format

Book4

	A	B	C	D
3	A. Standardization of NaOH:			
4	MW KHP:	**204.2**	g/mol	
5	DATA		DATA	RESULT
6	Mass KHP used	moles KHP used	Volume NaOH used	[NaOH]
7	(grams)		(mL)	moles/L
8	0.9450	0.004628	25.42	0.1736
9	0.9905	0.004850	26.87	0.1721
10	1.0553	0.005168	28.49	0.1729
11	0.9441	0.004623	25.30	0.1742
12	0.9468	0.004637	25.33	0.1745
13				
14			Average:	0.1735
15			SD	0.00098
16			%error	0.5651
17				

29 Sample calculation:

Moles KHP = 0.9450 g KHP [1 mole KHP] = 0.004412 moles
204.2 g

Moles NaOH = 0.004412 Moles KHP [1 mole NaOH] = 0.004412 moles
[1 mole KHP]

Volume NaOH = 25.42mL [1 Liter] = 0.02542 L
1000 mL

[NaOH] = 0.004412 molesMoles NaOH / 0.025.42 L NaOH) = 0.1736 M

BALANCED EQUATION: